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Psychological Traits And Trading Strategies

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Abstract

This paper analyzes experimentally if psychological traits and cognitive biases affect trading behaviour and performance. Based on the answers of 67 subjects to a psychological questionnaire we measured their degree of overconfidence, impulsiveness and self-monitoring, and their availability, representativeness and confirmation biases. The 67 subjects also participated in an experimental financial market, in the spirit of Plott and Sunder (1988). We find that impulsive subjects tend to place more orders but do not incur larger losses. We also find that overconfident subjects and subjects prone to the confirmation and representativeness biases have a greater tendency to place unprofitable orders. This negative impact of cognitive biases on trading performance is sronger when subjects have acquired some experience of the game. This suggests that biased subjects engage in improper learning.

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Psychological traits and trading strategies

1 Introduction

As far as observation is concerned, economists often focus on the inputs (the situation, the opportunities, the game, the information sets, etc...) and the outputs (the observed actions). Regarding the link between inputs and outputs, i.e. the reasoning and choice process of the agents, economists most often rely on theory and rarely focus on observations. In contrast with this rather behaviourist approach, psychologists collect observations on mental processes, by means of experimentation, questionnaires and interviews. The present paper is a preliminary endeavour to relate "psychology data" (collected through personality questionnaires) and "economics data" (collected in an experimental financial market).

While micro–economics offers an elegant and powerful framework within which human interactions can be analyzed, it is not obvious whether and how human subjects come to play equilibrium strategies or maximize profits. Experimental economics has shed light on this issue. It has identified situations where the predictions of economic theory are often rejected, for example when subjects act based on notions of fairness that are beyond the scope of the game (see Camerer, 1997). It also has identified contexts where micro–economics sometimes offer a rather satisfactory description of the behaviour to which subjects converge after several replications of the experiment. Experimental financial markets fall in that second category (see e.g. Plott and Sunder (1982, 1988), Forsythe and Lundholm (1990) or Biais and Pouget (1999)).

The goal of the present paper is to analyze empirically if the personality traits and decision styles of individuals (measured by a psychology questionnaire) predict their decision process and behaviour in an economic context (measured by strategies and performance in an experimental financial market). Among the issues we investigate are the following:

- Do personality traits such as impulsiveness or self–monitoring affect the behaviour of the subjects in the experimental financial market ?
- Do cognitive biases (such as overconfidence, confirmation bias or representativeness bias) lead subjects to make losses or deviate from optimal equilibrium strategies in the trading game ?

- Do learning and experience help the subjects to correct their psychological biases and reduce the impact of these on their behaviour ?

To address these issues we took the following steps:

- We constructed a psychological questionnaire borrowing from standard psychology measurement scales (such as Dickman's for impulsiveness, Snyder's for self–monitoring, or Russo and Schoemaker and Slovic, Lichtenstein and Fischhoff for over–confidence). We collected the answers to this questionnaire from 67 students.

- We let the same students play in an experimental trading game, in the same spirit as Plott and Sunder (1988). In this experimental financial market students can place limit and market orders to trade shares, based on their private signals about the liquidating value of the stock, and on their observation of the behaviour of the other players. Biais and Pouget (1999) show that, in the Arbitrage Free Perfect Bayessian Equilibrium of this trading game, there is full information revelation and traders do not place loss–making orders.

- We regressed the degree of activity of the subjects in the game, and the extent to which they placed profitable or unprofitable orders, onto 6 measures of psychological traits (impulsiveness, self–monitoring, over–confidence, confirmation bias, representativeness bias, availability heuristics) as well as control variables (including gender).

The empirical evidence points at links between some of the personality traits and the behaviour of the subjects in the experimental trading game. This is all the more striking that the questions asked to the subjects to measure the psychological traits had nothing to do with financial markets. Hence our evidence points at robustness of the psychological constructs independent of the context in which the questions are posed.

We find that impulsive subjects place more orders but do not incur larger losses. Hence while impulsiveness is found to affect behaviour, it is not found to be dysfunctional. We also find that overconfidence leads to unprofitable orders, consistent with the results obtained by Fenton O'Creevy et al. (1998) with real traders. The representativeness and confirmation biases are also found to reduce profitability mainly by hindering learning of the optimal strategies. This suggests that, for subjects who exhibit cognitive biases, experience generates improper learning (in the spirit of the theoretical analysis of Gervais and Odean, 1999). Rather than helping these subjects finding out what the profitable strategies are, experience induces them to build incorrect mental images (of what a typical situation is, or what is to be expected in the game) leading to unprofitable order placement strategies.

Our study of the interaction between psychological traits and economic behaviour is related to the insightful analyses of Camerer (1987), Forsythe et al (1992), and Barber and Odean (2000 a and b). Maybe the main methodological difference between their works and ours is that we endeavour to directly measure psychological traits and cognitive biases. We hope that this direct confrontation of psychological data and economic actions can provide information useful to ascertain the impact of psychological aspects on economic phenomena, and to identify which psychological dimensions are most important and in what way.

The next section presents the experimental trading game. Section 3 presents the psychological traits and the associated hypotheses. Section 4 presents the results. Section 5 offers a brief conclusion summarizing our results and sketching the next steps we plan to take in this research.

2 The experimental trading game

2.1 The trading game

The structure of the asset payoffs, the endowments and the signals are as in Market 7, Series C, in Plott and Sunder (1988) except that i) in the present case short sales are allowed, ii) there is a call opening auction before the continuous market and iii) after the opening call auction (and then also after the continuous market) the subjects are asked to write on a piece of paper the value of the stock they think the most likely, as well as the level of confidence of their forecast (high, medium or low).

There is a single risky asset, paying at the end of the game a liquidating dividend which can be 490 francs, 240 francs or 50 francs with equal probability. Before trading starts the players receive heterogeneous private signals. When the dividend is 490 francs, half the players know that it's not 240 francs while the other half know it's not 50 francs. Similarly when the dividend is 240 francs, half the players know it's not 490 francs, while half the players know it's not 50 francs, and when the dividend is 50 francs, half the players know it's not 490 francs, while half the players know it's not 240 francs. Each agent starts each replication of the game with 4 shares and 25000 francs. As in financial markets in the field, players can place market or limit orders to buy or sell.

Each replication of the trading game starts with an opening call auction. The subjects can transmit orders to the experimenter as sealed bids for up to ten shares at each price, written on a piece of paper. Using these orders the experimenter constructs an aggregate supply and an aggregate demand curve, and sets the opening price at the level maximizing trading volume. This price is announced publicly to the subjects. In addition the subjects receive written confirmations of the execution of their orders at the uniform opening price.

After the opening call, there is a continuous oral double-auction lasting seven minutes. During this period, the subjects can place limit orders for one share each in continuous time, by announcing them verbally to the experimenter. The experimenter writes these offers on the board. The other players see and hear the occurrence of these orders. They can hit these orders by placing market orders or marketable limit orders. Whenever this is the case transactions take place, and this is observed by the other players. As long as their orders have not been hit, subjects can cancel them.

Biais and Pouget (1999) show that in the arbitrage free perfect Bayesian equilibrium of this trading game there are no trade except at fully revealing prices (which is in the same spirit as the Milgrom and Stokey (1982) theorem), and that orders which if they were executed would result in losses are inconsistent with equilibrium.

2.2 Experimental design

We ran the experimental trading game with 7 different cohorts of students from Toulouse University. Subjects were graduate students in economics and management without previous exposure to experiments or market microstructure.[1] The experiment was run in the context of courses taught on stock markets. Each cohort included between 8 and 14 subjects. Each cohort participated to 4 replications of the experiment. We randomly drew the realizations of the final value of the asset.

The rules of the game were presented to the subjects in a one–hour class before the experiment. During this class the subjects asked questions and clarifications about the rules of the game. The experimenter endeavoured to

[1]2 cohorts were composed of students in the Masters in Finance (DESS de finance), 3 cohorts were composed of first year PHD students in management (DEA de Gestion), and 2 cohorts were composed of first year PHD students in financial economics (DEA Marchés et Intermédiaires Financiers).

answer all clarifying questions while refusing to discuss questions such as : How should I play ? What should I do in this circumstance ? Is this a good strategy ? etc... We explained to the students that we did not answer these questions in order not to influence their behaviour during the auction, we also announced them that, after the experiments we would have a debriefing session where we would analyze the game together. At the beginning of the experiment, each subject received a written document stating the rules of the game (an example is displayed in Appendix). The experimenter reexplained the game to the subjects, and they asked additional clarification questions. The subjects were also handed forms to write down the orders they placed during the preopening period or the opening call, and to record their trades, cash balances and inventories during the continuous market.

The subjects were instructed to maximize their final wealth. At the end of each replication the experimenter announced what was actually the realized value. Subjects then computed their final wealth. The experimenter checked these computations and then announced publicly and nominally the wealth of each of the subjects. The students were also announced verbally and in the written document that their grade for this course would reflect the final wealth they obtained in the replications. The grade for the course is between 0 and 20. There is a final exam, for which grades are typically between 6 and 14. Students participating to 4 replications of the game earned bonus points (to be added to their final exam grade to determine the course grade) equal to:

$$\frac{\Sigma_{I=1,\ldots,4}W_i - 95000}{2000}.$$

We believe that rewarding subjects based on exam grades, as opposed to relatively small amounts of money is likely to induce serious, optimizing behaviour, and to deter gambling or arbitrary and irrational attitudes.[2] To avoid influencing the students into trades that they did not feel beneficial, we repeatedly announced them during the experiments that they did not have to place orders and that their only concern should be to maximize their bonus.

[2]Note also that, from the pedagogic point of view, given that one of the most fundamental economic messages we want to convey to students in economics is profit maximization, this grading scheme seems appropriate.

3 Psychological traits and judgement biases

3.1 Hypotheses

This section presents psychological traits and judgement biases as well as hypotheses about their consequences on performance and behaviour in the trading game.

3.1.1 Impulsiveness

Impulsiveness is the tendency to act rapidly, without forethought (see e.g. Dickman, (1985, 1990), and Eysenck and Eysenck, 1977). Dickman (1985 and 1990) discuss the difference between dysfunctional impulsiveness, whereby the lack of forethought is a source of difficulty for the subject, and functional impulsiveness, whereby rapid reaction, without long thinking pauses, can be optimal. We formulate the following three hypotheses about the consequences of this psychological trait for trading behaviour in the game:

H1: Impulsive subjects are more likely to seize trading opportunities as soon as these arise, and consequently to place more frequent and numerous orders.

H1A: This is particularly likely to be the case in the continuous market, where real time fast reactions are involved. In contrast, in the call market, where students have time to ponder over decisions, impulsiveness is less likely to lead to greater market participation.

H1B: In the line of Dickman (1990), this hypothesis postulates that impulsiveness is not dysfunctional, and consequently should not result in unprofitable orders and trading losses. The alternative hypothesis is that impulsiveness is dysfunctional, so that for example subjects place orders before taking the time to consider adverse selection risk, which leads to loss–making orders and lower trading profits.

3.1.2 Overconfidence

Psychologists have found evidence that people tend to overestimate their abilities. For example, in a purely random situation, subjects tend to attribute (random) gains to their own skills (see Langer and Roth, 1975). When it comes to information processing, this tendency to overestimate one's abilities can lead to overconfidence in the precision of one's (public or private) information. Overconfident people attribute excessive precision to their beliefs. To assess overconfidence Fischhoff, Lichtenstein, and Phillips

(1982) and Russo and Schoemaker (1989) ask subjects to make range predictions such that they are 90 % sure that the actual value will fall within the range specified. Overconfident subjects give too narrow ranges, such that actual values fall outside the range more than 10 % of the time. Using this procedure with 36 foreign exchange traders, Stephan (1998) found evidence suggestive of pronounced overconfidence. Fenton O'Creevy et al (1998) find that traders subject to the illusion of control (measured by perceived ability to influence the movement of a point on a screen) were less likely to show successful performance in their professional operations. Odean (1998) analyzes a model where privately informed agents overestimate the precision of their signals. This leads to excessive trading and lowers their expected utility. Barber and Odean (2000a) find that individual investors who trade more often earn lower returns net of transactions costs. This result is consistent with overconfidence leading to excessive trading which in turn leads to underperformance. Barber and Odean (2000b) provide additional evidence on the trading activity and performance of individual investors by relating it to gender. Several psychological studies have found that men are more overconfident than women. Barber and Odean (2000b) argue that consequently men should trade more often than women and make lower profits. They find that in their individual investors data men do indeed trade more than women, and earn lower net returns, reflecting larger transactions costs.

In line with these analyses, we formulate the folllowing hypothesis regarding the consequences of overconfidence in our experimental trading game:[3]

H2A: Overconfident subjects trade more.

H2B: Overconfident subjects are less likely to update their beliefs about the value of the stock based on their observation of the actions of the others. Hence they are likely to suffer more from the winner's curse, and consequently place loss–making orders more frequently and earn lower profits.

3.1.3 Confirmation bias

A person suffers from confirmation bias if he or she tends to misinterpret ambiguous evidence as confirming his or her current hypotheses about the world.

[3]To distinguish the potentially different consequences of overconfidence and gender we include the latter as a control variable in our regression along with our index of overconfidence.

Wason and Johnson–Laird (1972) find experimental evidence that subjects seek confirmation rather than disconfirmation of prior hypotheses. They conduct an experiment with a deck of cards in which all cards have a letter on one side and a number on the other side. The subjects are told that the deck of cards could have the property that "if a card has a vowel on one side it has an odd number on the other side." The experimenter shows them four cards, with an "A", a "D", a "4" and a "7". The subjects are asked which card it is useful to turn to find out if the property holds. Subjects prone to the confirmation bias mention card "4", which cannot disprove the property, rather than card "A" which can disprove the property.

Plous (1991) shows experimentally that subjects initially opposed to nuclear power tend to interpret new evidence as suggestive of the dangers of this form of energy, while subjects initially in favor of nuclear power tend to give the opposite interpretation to the same evidence.

Forsythe et al (1992) analyze students' bets on the Republican and Democrat candidates in the 1988 Presidential election. Consistent with the hypothesis that people tend to interpret evidence as supportive of their prior positions, they found that a large number of subjects tended to believe that their favoured candidate had won the presidential debate. They also find that subjects who do not suffer from this bias (for example those who are in favor of the Democrats but realize that the debate was won by the Republican candidate) were able to trade at a profit with biased subjects. Forsythe et al (1992) discuss how these unbiased arbitrageurs played an important role in driving the political stock market towards efficiency. In line with the analysis of Forsythe et al (1992) we formulate the following hypothesis regarding the consequences of confirmation bias in the trading game:

H3: Confirmation bias is likely to hinder subjects from efficiently using market information to update their priors. This should lead to greater winner's curse, more frequent loss–making orders and lower profits.

Comparing H2 and H3, confirmation bias has the same consequences as overconfidence. This is in line with the theoretical analysis of Rabin and Schrag (1999) where confirmation bias leads to overconfidence.

3.1.4 Representativeness

In the representativeness heuristic the probability of A given B is evaluated by the degree to which B resembles A. This generates a bias if it leads to overestimating the probability of an event when observing data similar to this event (see Kahneman, Slovic and Tversky, 1982). For example, in the experiment run by Camerer (1987) there are two cages. In cage X two thirds of the balls are black while one third are red, and in cage Y two thirds of the balls are red while one third of the balls are black. Suppose three balls are drawn with replacement from one of the two cages, and this yields two black balls and one red ball. Representativeness bias leads to put a greater judged probability for cage X than required by Bayes law, because this draw resembles the content of cage X. The prices and allocations arising in the experimental market analyzed by Camerer (1987) are consistent with some traders suffering from representativeness bias. The degree of the bias is found to be small, however, and even smaller with experienced subjects. Also, Camerer (1987) conjectures that the winner's curse in common value auctions found by Kagel and Levin (1986) might be caused by a heuristic like representativeness. In line with the analysis of Camerer (1987) we formulate the following hypothesis:

H4: Representativeness bias prevents subjects from correctly taking into account market information, and consequently leads to losses.

3.1.5 Availability heuristics

Subjects using the availability heuristics assess the frequency of a class or the probability of an event by the ease with which instances or occurences can be brought to mind (see Kahneman, Slovic and Tversky, 1982). This can lead to biases to the extent that the ease with which instances come to mind may be imperfectly correlated with their frequency.

In the trading game, subjects prone to the availability bias might put too much weight on salient information, such as for example the opening price or recent market activity, and overreact to these news. This could undermine their trading performance.

H5: Subjects prone to the availability bias tend to place more unprofitable orders.

3.1.6 Self–Monitoring

Gangestad and Snyder (1986, page 125) define this construct as follows: "Individuals high in self monitoring are thought to regulate their expressive self–presentation for the sake of desired public appearances and thus be highly responsive to social and inter–personal cues of situationally appropriate performances." Self–monitoring has been studied extensively in social psychology and also applied to management (see for example DeBono and Snyder (1985) for advertising and Berscheid, Matwychuk and Snyder (1984) for personnel selection.) In the context of our experimental trading game one could expect subjects high in self monitoring to be more sensitive to the interpersonal dimension of the game, and better adjust their attitude and strategy to the behaviour of the others. Consequently, we posit the following hypothesis:

H6: Subjects high in self–monitoring suffer less from the winner's curse, place less frequently unprofitable orders, and earn larger profits.

3.1.7 Experience and judgement biases

When facing new and difficult problems, subjects may well exhibit judgement biases. But, as they become more experienced, and learn about the environment, they may process information more efficiently, so that the impact of judgement biases will be less strong. On the other hand, experience could have the opposite effect. Gervais and Odean, 1999, propose a theoretical analysis of how improper learning schemes, subject to the illusion of control, can lead to overconfidence. Also, new, unknown situations could perhaps intimidate subjects, preventing them from indulging in sloppy, biased information processing. In contrast, as the environment becomes more familiar, subjects could revert to their usual attitude and judgment biases. Furthermore, as they become experienced, subjects develop notions of what is a typical situation in the trading game. It is against this backdrop that they are liable to be subject to representiveness biases. In line with this discussion, we posit the following hypotheses:

H7A: As subjects become more experienced, they learn how to overcome judgement bias, and the impact of the latter on their behaviour becomes weaker.

H7B: As subjects become more experienced, they are more influenced by their judgemental biases, and consequently the impact of their psychological traits on their order placement behaviour becomes stronger.

3.2 Measurement

3.2.1 The psychology questionnaire

A week or two before the trading game the students were asked to fill a psychology questionnaire. One of the authors of the present paper (Karine Mazurier, who is a graduate student in social psychology at Toulouse University) handed the questionnaire to the students and asked them to fill it out explaining them that it would be useful for her research. She did not mention to the students that this was to be related to the experimental trading game, nor did she show up in that experiment (which was run by two other coauthors of the paper: Biais and Pouget).

The questionnaire included:

1. 6 items measuring impulsiveness (taken from Dickman, 1990).
2. 10 items measuring overconfidence, adapted from Russo and Schoemaker (1989) and Fischhoff, Lichtenstein and Phillips (1982).
3. 3 items measuring confirmation bias (one of them replicating Plous (1991) adapted to the French context, the other replicating Wason and Johnson–Laird (1972)).
4. 3 items measuring representativeness bias (one of them inspired by the experiment run by Camerer (1987) the others from Dawson, Shields and Slugoski (1993).
5. 6 items measuring availability bias, also from Dawson, Shields and Slugoski (1993).
6. the 18–items self monitoring scale constructed by Gangestad and Snyder (1986).

67 students completely answered the questionnaire and then participated to the game. 24 of these were girls and 43 were boys.

3.2.2 Indexes

Based on the answers to the questionnaire we constructed an index of each of the 6 judgment biases and psychology traits (representativeness, availability, overconfidence, confirmation bias, self–monitoring and impulsiveness). Answers to each question were coded. For each trait we summed the scores obtained for the different items. We then computed the mean and standard deviation across subjects of the corresponding numbers obtained. The indexes used in the empirical analysis result from substracting the mean and dividing by the standard deviation.

3.2.3 Reliablity

To assess the reliablity of the constructs, we computed their Cronbach α. While self–monitoring had a reasonably large score (.61), the other constructs have relatively low scores (.42 for overconfidence, .3 for availability, .28 for impulsiveness, and even lower scores for representativeness and confimation). These low reliability scores mean that we measure the underlying constructs with large errors. Such measurement errors will tend to reduce the significance of the variables when included as regressors in regressieons. On the other hand, as long as the errors have zero mean, they do not bias the slope coefficient estimates. Consequently, in the regression analyses below, if we find that the psychological variables are not significant, it can stem from the construct being indeed irrelevant, or from measurement errors. On the other hand, if in spite of measurement errors, the variablesare found to be significant, it suggests that they really matter.

Furthermore, we computed the correlations between the indices corresponding to the different constructs. They are presented in Table 1. As can be seen in the table, there is relatively low correlation between the indices, suggesting that they indeed measure different underlying traits.

4 Empirical results

The hypotheses presented above suggest that psychological traits and judgement biases can be expected to affect the number of orders placed by subjects and the profitability of these orders. To test these hypotheses we regressed variables characterizing trading strategies and performance across the 67 subjects onto the indexes of confirmation bias, overconfidence, availability bias, representativeness bias, impulsiveness and self monitoring described above. We also added in the regressors, as control variables, the gender of the subjects, the number of traders in the cohort, and dummies for the degrees in which the students were enrolled. The psychological indexes are centered, we also centered the control variables, so that in the regressions below the intercept is equal to the unconditional mean of the dependent variable and the impact of the regressors on the conditional mean can easily be computed.

4.1 The number of orders

Table 2 presents the estimates of the OLS regression when the dependent variable is the average number of orders per replication. Table 2, Panel A, contains the results for the number of orders, placed in the call or continuous market. Table 1, Panel B, presents the results obtained for the number of orders placed in the continuous market. The results can be summarized as follows:

- Although the psychological variables are likely to be measured with noise, the adjusted R^2 (23% and 34%) are reasonably large.
- On average subjects place 6.7 orders per replication, out of which 3.29 are placed in the continuous market.
- Consistent with Hypothesis H1 more impulsive subjects place more orders. Consistent with hypothesis H1A, this is particularly strong in the continuous market.
- Consistent with the findings of Barber and Odean (2000b) (which were based on field data) men trade more than women. In fact, in our data men place 60 % more orders than women. This difference is quite large (and is statistically significant) and is of the same order of magnitude as that reported in Barber and Odean (2000b): 45 %.
- In contrast with H2A, we do not find that our measure of overconfidence is correlated with more frequent order placement. This discrepancy can reflect several phenomena: On the one hand, it is possible that, in contrast with the argument offered by Barber and Odean (2000b), overconfidence does not lead to more frequent orders. On the other hand, it is possible that our measurement of overconfidence is not very good and that gender offers additional information, not captured by our questionnaire, useful to assess the level of overconfidence of a subject. In fact, in our questionnaire data, while the average overconfidence of men (0.02) is larger than that of women (-0.03), we do not find that the difference is significant (the t–statistic for the difference in means test is 0.174).
- We also find that the availability heuristics leads to less frequent order placement, a result we did not anticipate. A possible ex–post interpretation might be that when designing their trading strategies,

subjects using the availability heuristics find transactions leading to losses particularly salient, which reduces their propensity to engage in trades.

4.2 Unprofitable orders

In addition to being a natural measure of poor performance, the placement of unprofitable orders is inconsistent with the arbitrage free perfect Bayesian equilibrium of the present trading game (as shown in Biais and Pouget (1999)). Given the direction of the order (buy or sell), comparing its price to the final value of the asset, we determine if this order would generate profits or losses if it was executed.[4] Table 3 presents the estimates of the coefficients of the regression across subjects of the proportion of such orders (averaged across replications of the game) onto psychological traits and gender. Panel A corresponds to orders placed in the call or in the continuous trading phases. Panel B corresponds to orders placed in the continuous market only.

- Again, the adjusted R^2 (36% and 41%) are reasonably large.
- On average, 24 % of the orders placed in the call or the continuous trading phase are unprofitable, or inconsistent with equilibrium. When focusing on orders placed in the continuous trading phase only, the proportion is 22.78 %.
- There is no strong evidence that more impulsive subjects have a greater tendency to place unprofitable orders. Hence, while, as shown above impulsiveness increases trading frequency, the hypothesis that it is dysfunctional is rejected, except, marginally, when focusing on orders placed in the continuous trading phase.
- Consistent with H2, and with the analysis of Odean (1998), more overconfident subjects exhibit a significantly greater tendency to place unprofitable orders. That overconfidence is found to be significant in the present regression suggests that it is not measured with too much noise. Not only is the impact of overconfidence statistically significant, but is also arguably economicallly significant. While for the average subject

[4] Note that we thus categorize as unprofitable orders those which did result in losses as well as those which would have triggered losses if they had been executed.

the proportion of unprofitable orders is 24.2 %, for subjects with overconfidence one standard deviation above the average this proportion goes up to 28.8%. Furthermore our results, based on the correlation between actions taken by students in an experimental game and their answers to a psychology questionnaire, bear similarities with the results of Fenton O'Creevy et al (1998), based on the correlation between the actual profitability of real world traders and their behaviour in a psychology experiment. Note also that, in contrast with Barber and Odean (1999), we do not find that men exhibit a greater tendency than women to place unprofitable orders.

- Consistent with H3, subjects prone to the confirmation bias exhibit a greater tendency to place unprofitable orders. This is significant only in the continuous trading phase of the market, however. The interpretation can be the following: Based on their initial signal and the price established in the call market the subjects establish an initial view of the true value of the asset. Since the information available at that stage is limited, this initial view can be wrong. Subjects who are prone to the confirmation bias fail to correct such initial mistakes. This results in unprofitable orders. Along the line of H7B this can be interpreted in terms of "improper learning" in the same spirit as the theoretical result of Gervais and Odean (1998).[5]
- The availability bias, while it affects the number of orders, does not appear to influence the tendency to place unprofitable orders.
- Subjects who are high in self–monitoring do not tend to place relatively less unprofitable orders. This leads to rejecting hypothesis H6, all the more so that, unlike the other constructs we consider, self–monitoring is relatively well measured by our questionnaire.

4.3 Learning

If subjects learn to play equilibrium strategies as they become more experienced, the proportion of orders inconsistent with equilibrium (or equivalently of unprofitable orders) should be lower towards the end of the experiment than at the beginning. To provide information on this, we substracted, for each subject, the averge proportion of unprofitable orders during the first

[5]Improper learning may be at the root of information mirages in experimental markets. For studies of such mirages see for example Camerer and Weigelt (1991).

two periods from the average proportion of unprofitable orders during the last two periods. With learning, this difference should be negative. To examine the consequences of psychological traits on learning we regressed this difference across students onto the 6 psychological variables. As in the previous regressions we also included control variables in the regressors. Furthermore, to take into account error correction phenomena, we included in the regressors the proportion of unprofitable orders during the first two periods. This enables us to test if subjects who made many mistakes tend to learn and reduce the proportion of unprofitable orders they place. Here again, in order to be able to interpret the intercept as the unconditional expectation, we substract the cross sectional mean from the explanatory variable. The results of the regression are in Table 4. Panel A presents results obtained for all orders, while Panel B presents results obtained when focusing only on the orders placed in the continuous market.

The main results can be summarized as follows:

- Again, the adjusted R^2 are quite large (approximately 61%).

- The proportion of unprofitable orders during the first two replications of the game is highly significantly negative, both statistically and economically, which suggests that error correction phenomena are actually at work. Another result pointing at learning is that, in both panels, the intercept is significantly negative, i.e., subjects place unprofitable orders less frequently towards the end of the experiment.

- Furhermore, our results suggest that subjects prone to the representativeness bias learn less well than the others. This is particularly strong when focusing on orders placed during the continuous trading phase of the market, for which the variable is significant at the 1% level. Our interpretation is the following: At the beginning of the game subjects have only vague views of what to expect in the market. During the first two replications of the game, subjects establish stronger views of what is typical in the experiment, in particular at the stage of the call auction. If they are prone to the representativeness bias, they subequently believe excessively in the occurence of certain events, in the last two replications of the game, when observing what they interpret as typical, or representative, situations. This suggests that these subjects are conducting improper learning, consistent with hypothesis H7B.

- Our measure of confirmation bias is also found to hinder efficient learning, consistent with the interpretation offered in the previous subsection, and with H7B.

5 Conclusion

The results of this preliminary investigation can be summarized as follows:

- The empirical evidence suggests that there is indeed a correlation between some of the personality traits and judgement biases measured by the psychology questionnaire and the behaviour and performance of the subjects in the experimental trading game. This is all the more striking that the questions asked to the subjects to measure the psychological traits had nothing to do with financial markets. Hence our evidence points at robustness of the psychological constructs independent of the context in which the questions are posed.

- More impulsive subjects tend to place a larger number of orders, but they do not tend to place unprofitable orders more frequently. Hence while impulsiveness is found to affect behaviour, it is not found to be dysfunctional.

- Overconfidence does lead subjects to place unprofitable orders. This is consistent with the analysis of Odean (1998)) and the results obtained with real traders by Fenton O'Creevy et al (1998).

- The representativeness and confirmation biases also lead to unprofitable orders, mainly by hindering efficient learning of the optimal trading strategies. This suggests that, for subjects who exhibit representativeness and confirmation biases, experience generates improper learning (in the same spirit as the theoretical analysis of Gervais and Odean, 1999). Rather than helping these subjects finding out what the profitable strategies are, experience induces them to build incorrect mental images (of what a typical situation is, or what is to be expected in the game) leading to unprofitable order placement strategies.

While this draft is very preliminary we will endeavour to improve our analysis in the next drafts. In particular we plan to undertake the following analyses:

- One reason why confirmation bias leads to unprofitable orders in the continuous trading phase could be that subjects establish wrong beliefs during the call and fail to correct these afterwards. To test for this we plan to focus on the subset of replications in which the subject has formulated erroneous forecasts after the initial call market. We hypothesize that the impact of confirmation bias on the proportion of unprofitable orders will be stronger there.

- Also we will endeavour to analyze how judgement biases affect the ability of the subjects to form correct forecasts about the true value of the stock. To do so we plan to run 3 logit–regressions: In the first regression, the probability to form a wrong forecast after the opening call auction will be regressed onto the level of representativeness bias multiplied by the absolute deviation between the true value and the opening price. Our hypothesis is that this interaction variable should have a significant impact on mistaken forecasts. The idea is that subjects prone to the representativeness bias might incorrectly infer from the opening being close to, say, 240, that this is indeed the value of the stock. When the deviation between the opening price and the value is large this could lead to quite unprofitable orders. In the second regression, the probability to express a high level of confidence in a wrong forecast will be regressed on the level of overconfidence. In the third regression the probability to correct (after the continuous market) an initially wrong forecast (formulated after the call market) will be regressed onto the index of confirmation bias. Our hypothesis is that subjects prone to the confirmation bias are less likely to correct their initial mistakes.

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Appendix:Instructions to the subjects in the trading game

In this trading game you will have the opportunity to buy and sell shares. The instructions of the game are below. If you follow them carefully and make good decisions you can win a considerable amount of bonus points.

You will play 4 replications of the trading game. At the beginning of each replication you will receive 25000 francs and 4 shares. During the game you will have the opportunity to place orders to buy or sell the shares. (You can sell more shares than you own, i.e., short sales are allowed). At the end of each replication, you will compute the value of your final wealth, equal to the sum of:

- your initial cash: 25000 F,
- minus the cost of your share purchases,
- plus the proceeds from your share sales,
- plus the final value of your portfolio.

The final value of your portfolio is equal to the number of shares you own at the end of the replication, multiplied by the final value of each share. The final value of the shares, at the end of each replication, is drawn randomly (and independently from the previous draws). It can be 490, 240 or 50, with equal probability: one third. For example, if your only trade was the purchase of one share at price 200, and the final value of the shares is 240, your final wealth is: 25000 - 200 + 5* 240. Since you can sell more shares than you own, you can end up with a negative number of shares held at the end of the replication. For example, if you sold 6 shares at 100 each and the final value of the shares is 50, your final wealth is: 25000 +600 - 2*50, given that you have sold 2 shares more than you owned.

At the beginning of each replication you will receive a private information (keep it secret, don't reveal it to the others !). If the value of the shares is 490, half the players know it is not 240, while the others know it is not 50. If the value of the shares is 240, half the players know it is not 490, while the others know it is not 50. If the value of the shares is 50, half the players know it is not 240, while the others know it is not 490.

Each replication of the trading game includes two phases:

First, you can place limit orders to buy or sell (up to 10 shares at each price), by writing them on a piece of paper. These orders are then aggregated into supply and demand curves, crossed to determine the opening price, in a call auction. The opening price is set to maximize trading volume, as explained in class. This price, but not the orders, is announced publicly to the players. After this annoucement, you receive execution reports, telling you which of your orders are filled. All limit sell orders placed at prices below or equal to the opening price are executed at this price. All limit buy orders placed at prices above or equal to this price are executed at the opening price. The remaining orders are not executed. For simplicity, they automatically cancelled after the opening call.

Second there is continuous market, which lasts 7 minutes, during which you will have the opportunity to:

- announce offers to sell or buy, which I will write on the board (to make life easier for me when I write the offers on the board, they are all for one share only, but you can place many offers),
- announce that you desire to trade with one of the offers available on the board, and which have not been executed yet;
- cancel or revise your offers when they have not been executed yet.

After the 4 replications, you will compute the sum of your final wealth during the game. To obtain the number of bonus points to be then added to your grade at the exam, substract 92000 to this sum, and divide the result by 3000.

Table 1: correlations across psychological indexes

Correlation across the 6 psychological indexes

Indexes	Impuls.	Availab.	Monitoring	Repres.	Overconf.	Confirm.
Impulsiveness	1	0.21	0.18	-0.05	0.13	0.02
Availability		1	0.09	0.19	0.09	-0.12
Self Monitoring			1	-0.05	0.20	0.05
Representativeness				1	-0.27	-0.19
Overconfidence					1	0.03
Confirmation bias						1

Table 2.A: total number of orders

Regression across the 67 subjects of the total number of orders (averaged across the 4 replications of the game) on psychological traits and control variables.

Variables	Coeffs	t-stats
Constant	**6.71**	15.27
Impulsiveness	0.82	1.73
Availability	**-1.39**	-2.83
Self Monitoring	0.13	0.26
Representativeness	0.23	0.47
Overconfidence	-0.14	-0.28
Confirmation bias	-0.57	-1.17
Gender (Male=-0.34; Female=1)	**-2.01**	-2.98
Number of traders per cohort	**-1.66**	-2.10
Masters in Finance	0.31	0.33
PHD in Management (first year)	1.79	1.28
Adjusted R^2	23%	

Table 2.B: number of orders placed during the continuous phase

Regression across the 67 subjects of the number of orders placed during the continuous phase (averaged across the 4 replications of the game) on psychological traits and control variables.

Variables	Coeffs	t-stats
Constant	**3.29**	12.53
Impulsiveness	**0.72**	2.52
Availability	**-0.69**	-2.34
Self Monitoring	0.26	0.86
Representativeness	0.44	1.53
Overconfidence	0.14	0.48
Confirmation bias	-0.02	-0.09
Gender (Male=-0.34; Female=1)	-0.78	-1.94
Number of traders per cohort	**-1.06**	-2.23
Masters in Finance	-0.94	-1.67
PHD in management (1st year)	0.90	1.07
Adjusted R^2	0.34	

Table 3.A: proportion of unprofitable orders

Regression across the 67 subjects of the proportion of unprofitable orders (averaged across the 4 replications of the game) on psychological traits and control variables.

Variables	Coeffs	t-stats
Constant	**0.24**	15.23
Impulsiveness	0.02	1.00
Availability	-0.00	-0.35
Self Monitoring	0.00	0.09
Representativeness	0.02	1.19
Overconfidence	**0.05**	2.61
Confirmation bias	0.02	1.34
Gender (Male=-0.34; Female=1)	-0.01	-0.45
Number of traders per cohort	-0.05	-1.58
Masters in Finance	**-0.10**	-2.85
PHD in management (1st year)	-0.08	-1.50
Adjusted R^2	36%	

Table 3.B: proportion of unprofitable orders placed during the continuous phase

Regression across the 67 subjects of the proportion of unprofitable orders during the continuous phase (averaged across the 4 replications of the game) on psychological traits and control variables.

Variables	Coeffs	t-stats
Constant	**0.23**	11.91
Impulsiveness	0.02	1.15
Availability	0.00	0.00
Self Monitoring	0.02	0.73
Representativeness	0.04	1.92
Overconfidence	**0.05**	2.20
Confirmation bias	**0.05**	2.64
Gender (Male=-0.34; Female=1)	-0.02	-0.65
Number of traders per cohort	**-0.11**	-3.19
Masters in Finance	-0.07	-1.67
PHD in management (1st year)	0.01	0.11
Adjusted R^2	41%	

Table 4.A: change in the proportion of unprofitable orders

Regression across the 67 subjects of the difference between the proportions of unprofitable orders during the last 2 and the first 2 replications of the game on psychological traits and control variables.

Variables	Coeffs	t-stats
Constant	**-0.05**	-2.04
Impulsiveness	0.03	1.02
Availability	-0.02	-0.75
Self Monitoring	0.00	0.03
Representativeness	0.04	1.59
Overconfidence	0.03	1.17
Confirmation bias	0.04	1.42
Gender (Male=-0.34; Female=1)	-0.02	-0.44
Number of traders per cohort	-0.08	-1.75
Masters in Finance	-0.04	-0.64
PHD in management (1st year)	0.02	0.26
First 2 replications	**-0.30**	-9.13
Adjusted R^2	61%	

Table 4.B: change in the proportion of unprofitable orders placed during the continuous phase

Regression across the 67 subjects of the difference between the proportions of unprofitable orders placed in the continuous phase during the last 2 and the first 2 replications of the game on psychological traits and control variables.

Variables	Coeffs	t-stats
Constant	**-0.06**	-2.56
Impulsiveness	0.05	1.83
Availability	-0.01	-0.27
Self Monitoring	0.01	0.18
Representativeness	**0.09**	3.12
Overconfidence	0.05	1.60
Confirmation bias	**0.07**	2.59
Gender (Male=-0.34; Female=1)	-0.03	-0.79
Number of traders per cohort	**-0.15**	-3.17
Masters in Finance	0.00	0.01
PHD in management (1st year)	0.16	1.87
First 2 replications	**-0.29**	-8.73
Adjusted R^2	61%	